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NATURAL MINERAL-PAINT EXTENDERS

BY

CHARLES L. HARNESS

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UNITES STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

NATURAL MINERAL-PAINT EXTENDERS[1/]

By Charles L. Harness[2/]

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INTRODUCTION

Fifty years ago, the belief that "fillers" were added to paints for the sole purpose of diluting and cheapening the pigment may have been justified; but paint technology has made tremendous progress since that time, and today both the manufacturer and the consumer know that the judicious use of fillers may add desirable properties to a paint that cannot be introduced in any other way. A growing respect for these accessory materials has led to the use of the more euphemistic term "extender." The names "extender" and "filler" are to a considerable degree synonymous. The newer term, "extender," is adopted in this paper, though it is actually no more descriptive than the older name. Stewart's[3/] definition of extender is: "A cheap pigment, usually of an inert type, used to extend or increase the bulk of a paint, thus reducing its unit cost. Extenders are also used to adjust the consistency of a paint and to let down colored pigments of great tinting strength. The use of an extender in a paint does not necessarily mean the resultant product will be inferior. In fact, extenders sometimes improve certain characteristics of a film." All extenders are not cheap, as, for example, wet-ground mica and diatomite.

Research on the use of extenders (also sometimes called "inerts") has been one of the most active branches of study in the paint field, and many thousands of dollars have been spent in establishing the physical and chemical characteristics required of various natural mineral extenders for numerous paint formulas.

Virtually all extenders have low refractive indexes, averaging about 1.5, which is about the same as that of the common drying oils. Consequently the extenders reflect but little light and have little covering or hiding power. The hiding power of extenders can be increased slightly by careful grinding and sizing, producing a smaller particle, but this is seldom economical. Also, there are definite optimum particle sizes; if the grain is smaller than the wave length of the light striking it, it tends to act as a single point of light propagation, permitting the long waves of red light to continue in a straight line but scattering the short waves of blue and violet light at right angles to the path of incidence. Down to this limiting grain size, however, the reflecting surface of a given volume of extender increases with fineness of grain. (For most pigments the optimum particle size is 0.5 to 1.0 microns, as compared with a range of 5 to 25 microns ordinarily encountered in extenders.)

Generally speaking, hiding power increases with increase of refractive index, fineness of particle (though not smaller than optimum size), depth of

3/ Stewart, J. R., National Paint Dictionary: Stewart Research Laboratory, 1942, p. 54.

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color, and in certain extenders with the roughness and complexity of the grain.

Following are the principal purposes for which extenders are added to paints:

(1) To dilute primary pigment in the manufacture of inexpensive paints. (Barite, clay, sericite, whiting.)
(2) To facilitate suspension. (Mica, bentonite, kaolin, talc.)
(3) To increase resistance to moisture. (Mica, sericite.)
(4) To strengthen paint film. (Mica, sericite, talc, diatomite.)
(5) To give characteristic finish to flat paints and lusterless enamels. (Talc, kaolin, diatomite.)
(6) To thicken primers. (Kaolin.)
(7) To improve sanding properties. (Barite, quartz, diatomite.)
(8) To increase density of film. (Barite.)
(9) To aid working with brush. (Barite, diatomite.)
(10) To assist primers in filling pores (Diatomite, talc.)
(11) To enhance wearing properties of paint folms exposed to abrasion. (Diatomite, talc, quartz.)

In the following sections the various extenders are discussed separately.

TALC

Description

The generally accepted formula of talc, $H_2Mg_3(SiO_3)_4$, requires a theoretical analysis of 63.2 percent SiO_2, 32.1 MgO, and 4.7 H_2O. However, published analyses range from 57 to 62 percent SiO_2 and 28 to 32.4 percent MgO. Al_2O_3, FeO, Fe_2O_3, MnO_2, and CaO are reported in some analyses. According to Joachim,4/ a talc marketed as "asbestine" consists of 85.3 percent hydrated magnesium silicate, 9.9 percent calcium silicate, 2.4 calcium carbonate, and 0.6 moisture at 105° C. The analysis appears to be somewhat variable, the following also having been reported: 92 percent magnesium silicate, 4 percent calcium silicate, 4 percent water of crystallization, and less than 0.5 water at 105° C.

Pyrophyllite, $H_2Al_2(SiO_3)_4$, is similar to talc in mode of occurrence, physical properties, and uses.

Two types of talc are used in paints - fibrous ("asbestine") and flake or platy. Fibrous talc is a mixture of tremolite, $Ca_2Mg_5(OH)_2(Si_4O_{11})_2$, and

4/ Joachim, Benjamin, Applied Paint and Varnish Chemistry: American Paint Journal Co., St. Louis, Mo., vol. 1, 1934, p. 59.

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talc. The fibrous talcs of St. Lawrence County, New York, are alteration products of tremolite in which the tremolite fibers have not been completely altered to talc. Commercial flake talc is a schistose mixture of talc and a carbonate mineral.

Preparation

There seems to be no fundamental difference in processes for milling fibrous or platy talc. Generally, the crude mineral is first broken in a jaw crusher, although sometimes a hammer mill is employed. Subsequent steps vary in different plants. One firm uses a roller mill, then a ball mill, followed by fine grinding in large tube mills in closed circuit with an air separator. The paint-grade product is about 99.6 percent minus 325-mesh and weighs about 33 pounds per cubic foot, packed. At other operations a disk crusher may be used between the jaw crusher and roller mill, and the ball mill may be omitted. Micronizers may be used instead of (or in addition to) tube mills.

Use in Paint

Talc is used in paint mainly as a suspending agent, as a flatting agent, and for film reinforcement. According to Joachim,[5/] the main paint use of talc is in oil paints. Unlike zinc oxide and certain other chemical pigments, talc cannot absorb the actinic rays of the sun, and therefore a large percentage of talc in the paint formula will encourage breakdown of the oil film and chalking, owing to the lack of protection from the sun. Large amounts of talc also stiffen the paint and prevent free flowing.

Talc is used in medium-gloss paints to reduce the porosity of the drying oil film and to improve resistance to checking and cracking. Only small quantities can be used in such paints, however, as talc tends to remain at the film surface and make it dull or flat. Talc is not used at all in high-gloss paints, as minute amounts cause appreciable loss of gloss. In dull-finish and flat paints talc is used in large quantities, particularly in camouflage-painting of army, navy, and air corps equipment. Talc is very useful in producing a "short" paint suitable for stippling or combing.

According to Bradley,[6/] talc is used in outside-paint formulations and in paints subjected to washing and abrasion.

5/ Work cited, vol. I, pp. 57-61.

6/ Bradley, J. R., Jr., Colorless Pigments of Low Refractive Index (L.R.I.): Chapter in Protective and Decorative Coatings, vol. II, p. 454, Published by J. Wiley & Sons, New York City, 1942.

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Fibrus talc has become the standard extender for use in first-grade commercial house paints made with white lead, zinc oxide, titanium dioxide, and lead titanate as the hiding pigments.7/

The following table indicates the extent to which talc is used in paints in the United States:

Talc, pyrophyllite, and ground soapstone sold by producers in the United States, 1936-42, for use in paint.1/

Year	Short tons	Year	Short tons
1936	56,613	1940	67,875
1937	59,660	1941	120,319
1938	53,506	1942	125,518
1939	67,859		

1/ Compiled from Minerals Yearbook, Bureau of Mines; data previous to 1936 not available.

MICA

Description

The theoretical formula of muscovite mica is $H_2KAl_3(SiO_4)_3$, and the theoretical analysis is SiO_2, 45.2 percent; Al_2O_3, 38.4; K_2O, 11.8; and H_2O, 4.6 percent. Actually, the alumina and potash may be lower if impurities, such as iron oxide, soda, magnesia, and titania, are present. Frequently the water content exceeds 4.6 percent, and it may be as high as 5.5 percent.

Muscovite plates over one-eighth inch thick may be almost opaque as a result of staining. This discoloration may not be apparent in very thin sheets, which appear perfectly transparent, unless contaminated with visible and discrete spots or streaks of iron oxide.

Because of its perfect basal cleavage, muscovite mica may be ground into flat plates, the thickness ranging from 1 to 10 percent of the width, which varies from 2 to 40 microns. Ground schists (chlorite, biotite, or sericite) have thicker plates than those obtained from muscovite or phlogopite, as the cleavage is not so well developed. For paint use, a thickness-width ratio of 1 to 10 or more is desirable.

Preparation

Mica must be wet-ground for use in paint, as dry-grinding destroys the luster and sheen and crumples the individual particles. There is some

7/ Fuller, W. R., Inert Materials for Admixture with Paint Pigments: A.S.T.M. Bull. 105, August 1940, pp. 35-8.

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variation in machinery used to wet-grind mica, but the favored apparatus today is a wooden chaser mill, consisting of a hardwood-bottomed pan 10 feet in diameter, on which roll two large wooden wheels. The mill generally has a capacity of 2,000 pounds of mica every 8 hours. The charge may consist of mine scrap, shop (cutting) scrap, or both. After the mica scrap is charged into the mill, water is added for lubrication - only a little at first, but later, as the mica disintegrates, enough to maintain a thick paste containing about 45 percent moisture. More water must be added from time to time, as friction soon raises the temperature of the mixture to the boiling point, and the mica may "burn" and lose its sheen if too little water is present. After an 8-hour grind, the charge may be washed out into a trough and the coarse settlings returned to the mill. At some works more water is added to the charge as it rests in the mill, and the fine material is allowed to drain off, leaving the oversize for grinding. When the mica has settled in the settling tank, the water is siphoned off and the mica dried on steam-heated tables and sifted through bolting cloth or bronze screens. A coagulant (such as alum) may be added to settle the finest particles, or they may be dewatered in a filter press.

Use in Paint

Wet-ground mica is said to facilitate suspension and reduce checking, cracking, and chalking in paints and to make the paint film moisture-resistant. Some authorities claim that mica has poor wetting and leveling properties.

The vehicle in casein paints tends to shrink on drying, and stains are developed much more rapidly in casein films than in drying-oil films. An extender in casein wall paints that permits shrinking and shearing of the film without visible cracking is a necessity, and mica is said to be such a one.

Mica is also used as a constituent of primers and sealing paints over rough and porous surfaces such as fiber board or insulating lumber. It is used in varnishes to protect metal surfaces from corrosion, as a component of aluminum-powder paints, and in certain fire-resistant paints.

When ground with colored pigments, mica increases brightness and, owing to its transparence, does not modify the tone. Mica is not opaque to ultraviolet light.

Mica has been most widely employed in paints made with zinc sulfide and leaded zinc oxide. It may be conveniently introduced in the form of a composite pigment containing 50 percent zinc sulfide, 40 percent talc, and 10 percent mica. Mica probably should not exceed 10 percent of total

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pigment; in greater quantities, its undesirable properties, such as glistening in bright light, poor wetting, non-uniform gloss, and poor leveling, become noticeable.8/

Sales of wet- and dry-ground mica 1/ for use in paint, 2/ 1936-42 3/

Year	Short tons	Value	Year	Short tons	Value
1936.....	1,307	$71,155	1940	1,874	141,192
1937.....	1,011	69,125	1941	4,020	253,294
1938.....	1,666	117,595	1942	6,819	418,548
1939.....	1,916	144,235			

1/ Includes some sericite.
2/ Compiled from Minerals Yearbook, Bureau of Mines.
3/ Data previous to 1936 not available.

Sericite

Sericite is a variety of muscovite mica consisting of fine, scaly aggregates with a silky luster. It commonly results from the alteration of feldspars. Sericite, a relatively new commercial extender, appears to contribute many of the moisture and film-protecting properties of wet-ground muscovite mica and can be sold in comparable mesh sizes for about half the cost of muscovite. Lump sericite is broken up in a hammer mill and is then wet-ground in a ball mill. The sludge is run into a gravity cell to remove quartz particles. Daily output in a sericite plant is greater than in a mica-grinding unit using the same power, owing to the comparative ease of disintegrating the sericite into small flakes. Sericite has good flatting action and has been used in olive-drab paints for automotive equipment. It has been used as a substitute for some of the aluminum powder in paint. A new water paint has been developed that uses soybean meal protein as the organic binder; 16 percent of the solids in the paint is sericite. An outdoor paint has been formulated, using an alkyd resin and sericite.

Vermiculite

Vermiculite, commonly an altered phlogopite mica, has the property of expanding to a maximum of about 16 times its original volume when heated. Nearly all of it is used as an aggregate for heat and sound insulation cements, but, some has also been used experimentally in recent years as a replacement and diluent in bronze-powder paints for gold and silver colors.

8/ Fuller, W. R., work cited in footnote 7.

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CLAY

Description

China clay (kaolin), the principal type of clay used as a paint extender, consists chiefly of kaolinite, which has the composition $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ and which theoretically contains 46.6 percent silica, 39.5 percent alumina, and 13.9 percent water. However, analyses of commercial china clay generally show less water, a little more silica and alumina, and frequently up to about 1 percent of impurities such as iron oxide, lime, magnesia, and alkalies. China clay is a fine, white, amorphous powder having slight adhesive properties but adhering to the fingers when moist; the best china clays feel soft and unctuous and have a good white tint.

Preparation

The impure clay is generally broken up in a log washer, and the suspension is passed into a series of troughs, where the sand and mica settle. The suspension runs through a 100-mesh screen into settling tanks. When it settles, the water is drawn off and the wet clay is pumped into filter presses. The cakes are dried by natural or artificial heat. It has been found very difficult to dewater the finest kaolins by means of the filter press, owing to the high content of colloidal particles, which tend to form a gelatinous mass. In recent years desirable colloidal kaolins have been dewatered successfully with centrifuges and made available as high-grade extenders.9/

Ries 10/ has summarized general methods of clay preparation.

It is important that a large fraction of the clay be of colloidal fineness for use in paint, so that it will remain suspended in the vehicle.

Use in Paint

Nearly all clays have certain disadvantages which prevent greater use in paint. Oil absorption is comparatively high - 100 grams of clay require 30 to 50 grams of linseed oil to make a plastic paste, compared with about 8 grams of oil for white lead. The hiding power is poor, as the index of refraction of the clay is about that of the vehicle. No free alkali or acid is permitted in a clay filler, as this might affect both the pigment and the drying oil. The clay should mix readily with the oil without coagulating.11/ Many clays which appear satisfactory in all other respects may turn green or brown when mixed in oil. The clay should pass a 325-mesh screen.

9/ Maynard, P., The fillers - clay, talc, etc., 1918-1938: Chem. Ind., vol. 63, No. 6, November 1938, p. 491.

10/ Ries, H., Clay: Chapter in Industrial Minerals and Rocks, 1937, p. 232.

11/ See Weigel, W. M., Georgia and Alabama Clays as Fillers: Bureau of Mines Tech. Paper 343, 1925, 35 pp.

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According to Heaton,12/ china clay is sometimes used as an extender in oil paints on account of its low specific gravity, which helps to prevent pigments from settling, but if used in any large proportion it gives the paint a soapy working quality and tends to produce a weak film when dry.

In American paint technology, clay is more important and probably less expensive than in the British industry. In the United States, clay for paint use ranges in cost from $7 to $16 a ton, f.o.b. works. Clays are used to improve the finish of flat paints and calcimines, to provide high consistency in primers, and to prevent the pigment from settling in oleoresinous paints. Very fine clays are used to some extent in enamels.13/

Bentonite, a true colloidal clay formed by the alteration of volcanic ash and tuffs is produced principally in Wyoming, South Dakota, California, and Texas. It has been recommended for use in cold-water paints, calcimines, enamels, printers inks, and oil paint on account of its ability to form stable suspensions.

Consumption of china clay and kaolin in paint in the United States, 1921, 1925, and 1930-42 in short tons1/

Year	Filler or extender	Calcimine	Total
1921	6,949	3,599	10,548
1925	11,889	2/4,694	16,583
1930	9,176	2/2,481	11,657
1931	8,828	2/1,752	10,580
1932	5,469	2/1,822	7,291
1933	5,739	4,535	10,274
1934	6,901	4,576	11,477
1935	7,162	2,962	10,124
1936	10,429	3,233	13,662
1937	5,343	1,884	7,227
1938	4,294	3,565	7,859
1939	6,018	3,642	9,660
1940	7,144	2,872	10,016
1941	12,793	1,660	14,453
1942	15,289	1,403	16,692

1/ Compiled from Mineral Resources of the United States, published by the U. S. Geological Survey and Bureau of Mines, and Minerals Yearbook, Bureau of Mines; values not published.

2/ Includes paint pigment as follows: 1925, 416 short tons; 1930, 560 tons; 1931, 133 tons; and 1932, 57 tons.

12/ Heaton, Noel, Outlines of Paint Technology: 2d ed., p. 111.

13/ For further discussion of properties and uses of clay in paint, see pp. 437-440 of footnote 6.

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BARITE

Description

Barite, $BaSO_4$, has a theoretical analysis of 65.7 percent BaO and 34.3 percent SO_3 but may contain small amounts of organic matter, strontium, calcium, and siliceous material such as clay. Consumers usually require material analyzing 95 percent $BaSO_4$ with a maximum of 1 percent Fe_2O_3. Barite is fairly soft (2.5 to 3.5 on Moh's scale) and grinds easily. The index of refraction is low (1.6+); consequently the mineral is virtually transparent in oil vehicle. Pure barite is white and opaque to transparent. When slightly impure, it may be yellow, blue, brown, or red. It is found in crystals and in granular, fibrous, or reniform masses; it is also lamellar, nodular, or earthly. The specific gravity is 4.3 to 4.7. When ground, particles have a vitreous to pearly luster and an uneven fracture.

Preparation

As a first step in removing clay, the lump barite is piled in the open and allowed to weather. Most of the clay can then be chipped off easily, and the lump is further cleaned by logwashing. If barite is stained with limonite, one of three methods for its removal is followed: (1) Roasting and removal with a high-intensity magnetic separator; (2) leaching the ground material (14 mesh or finer) with dilute sulfuric acid; and (3) crushing, calcination, and screening, whereby the barite passes through the screens and the limonite is rejected.

For use in paint, barite is generally ground in a conical ball mill equipped with an air classifier. This process gives a minus-325 mesh product.

Use in Paint

Though barite has poor hiding powers, it has advantages that warrant its use in paint. It has low oil absorption, fair sanding properties, and contributes to a dense, nonporous film. However, its cost of about 75 cents per solid gallon is high for an extender. Ground barite does not absorb ultraviolet light and consequently offers no protection to the film in outside paints. Its coarsness and high specific gravity tends to cause settling and caking in the paint can.

Considerable quantities of barite can be incorporated without bodying, owing to the low oil absorption. Its low tinting strength makes ground barite a good base for both colored and white pigments.

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Ground barite sold by producers for use in paint in the United States, 1938-42[1]
(Does not include barite sold for lithopone manufacture).

Year	Short tons	Year	Short tons
1938	8,227	1941.....	31,009
1939	9,750	1942.....	18,484
1940.....	11,056		

1/ Compiled from Minerals Yearbook, Bureau of Mines; data previous to 1938 not available.

WITHERITE

Witherite, barium carbonate, is little used as an extender in the United States, as deposits are small and rare. It has been used in England, however, as a substitute for war-scarce barite. Its properties are similar to those of barite, except that it is soluble in acid media, and paints containing it should not be used in coating food containers or other articles that might contaminate food products.

GROUND QUARTZ

Description

Silica particles, made from silica sand, quartz, and flint, are sharp and hard and have an average size of 2 to 5 microns. The bulk is a hard-feeling white powder. A typical analysis of ground quartz is silica, 99.0 percent; R_2O_3 (chiefly alumina, iron oxide, and titania), 0.5 percent; and loss of ignition, 0.5 percent.

Preparation

Quartz is generally calcined to convert it from alpha to beta quartz because the transformation is accompanied by a change in volume, which facilitates pulverizing. The typical crushing scheme includes jaw crushers, roller mills, pebble mills (less often, ball mills), either wet or dry, followed by hydroclassifiers or air separators.

Use in Paint

Owing to its inertness and durability, silica is used in outside house paints. The roughness of the extender is useful in flat wall paints and primers, to which it adds "tooth" and improves brushing. Graphite paints have a tendency to spread out in uselessly thin films, and this is easily corrected

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by adding silex. Silica is said to improve the life of traffic paints. It is sometimes used in heat-resistant paints.14/

The danger of silicosis through inhalation of fine particles of ground quartz or other silica may be reduced by proper use of dust masks and installation of vacuum systems. After the powdered material has been wetted with the paint vehicle, there is no further danger, of course.

Silica may settle badly on standing in a paint can unless the paint is properly formulated with suspending agents.

DIATOMITE

Description

When dry, diatomite15/ resembles chalk but is much lighter and more porous. Owing to its low apparent density (0.2 to 0.6), it will float on water until saturated. Pure diatomite does not seem gritty when tested between the teeth. Ground diatomite is not plastic when wet. Diatomite ranges in color from a pure white to a dark brown or black. Frequently, the discoloration is caused by the presence of organic matter, which may be burned out, leaving a pure-white diatomite. Iron discoloration cannot be removed by calcining.

Examination under a microscope is the surest test for diatomite and will also reveal the condition of the diatoms and diatom fragments, which range in size from 1 to 40 microns.

A typical analysis of good-quality diatomite follows: SiO_2, 86.24 percent; Al_2O_3, 3.05; Fe_2O_3, 1.02; CaO, 0.18; MgO, 0.65; H_2O at 105° C., 5.62; and CO_2 and organic, 1.20 percent.

Preparation

Crude diatomite, after preliminary crushing, is dried, ground in hammer and roll mills, and purified and classified simultaneously by a series of treatments with pneumatic blowers, separators, and classifiers.

14/ American Society Testing Materials, Symposium on Paint Materials: March 6, 1935, p. 114.

15/ Diatomite is also known as diatomaceous earth, kieselguhr, tripolite, fossil flour, desmid earth, bergmehl, radiolarian earth, polirschiefer, white peat, moler, molera, tellurine, and by trade names such as "Dicalite," "Celite," "Filter-Cel," "Speed plus," "L Grade," and others. Sometimes (but incorrectly) it is called infusorial earth.

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Uncalcined and calcined powders are produced in a number of particle-size ranges. Calcination is carried out principally in rotary kilns. A simplified flow sheet of the process has been published.16/

Use in Paint

The index of refraction of diatomite is so close to that of the vehicles that the hiding power is very low; consequently diatomite has little pigmenting value. One producer claims the following advantages of diatomite as a paint extender: It promotes adhesion; increases resistance to blistering, peeling, chalking, and cracking; increases durability and resistance to abrasion; improves brushing, leveling, and drying properties; takes sanding easily; and improves washability of the film. Oil absorption ranges from 35 to 300 percent, a fact to be considered when formulating.

As it comes from the quarry, diatomite is moist and can absorb water up to 220 percent of its dry weight. When the material has been calcined, water absorption drops to about 150 percent, and the actual moisture content is negligible. Moisture, even in small amounts, tends to produce bodying that may cause difficulty in paints made according to a specification that stipulates a maximum viscosity. On the other hand, the heavier body of paints made from moisture-containing diatomite may actually be desirable in flat paints, which could then dispense with such bodying agents as waxes, soaps, and alkali emulsions. Flat paints may contain about half a pound of diatomite per gallon of paint.

Diatomite is used as an extender in pigmented paints; as a flatting agent in lusterless enamels, varnishes, and lacquers; in primers; surfaces; and undercoaters; and in shingle stains, putties, and wood fillers. In painting porous surfaces, such as those of wood, brick, concrete, or stucco, it is necessary to produce a film that will permit moisture to escape. Diatomite aids in the formation of a porous film and consequently improves resistance to blistering.

The main use of diatomite is paint is in flat finishes, because its flatting power is exceptional; also it gives a good dull or matt effect and tends to prevent hard setting of the heavier pigments. The use of diatomite in traffic paints is increasing; 10 percent of diatomite per weight of total pigment has been recommended.

16/ Chem. and Met. Eng., vol. 49, No. 8, August 1942, pp. 110-3 to 113-8. See also Manning, Paul D. V., Modern Production Methods in Refining Diatomite: Chem. and Met. Eng., vol 45, No. 1, January 1938, pp. 28-31; and Mulryan, Henry, Geology, Mining, and Processing of Diatomite at Lompoc, Santa Barbara County, California: Am. Inst. Min. Met. Eng. Tech. Pub. 687, 1936, 30 pp.

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It has been found that between 35 and 65 percent of the total extender is a suitable range for formulating with diatomite. For example, a formula for the extender portion of the lusterless olive-drab synthetic enamel reads as follows: Magnesium silicate, 35 percent; barite, 30 percent; and diatomite, 35 percent. This inert formulation appears to give the desired bulk and at the same time gives rapid drying. The cost of diatomite is 38 to 48 cents per solid gallon.

TRIPOLI

The term "tripoli" is applied to a number of soft, porous, friable sedimentary silicas of inorganic origin, generally assumed to be residues of the decomposition of highly siliceous limestones or dolomites, or a decomposition product of chert.

To prepare it for paint use, crude tripoli is air-dried, crushed to pebble size, then wet- or dry-ground in a pebble mill, followed by bowl or air classification, as the case may be. Extender grades are generally required to be 95 percent or more through 325 mesh.

Tripoli increases the durability of outside paints when added in small amounts and also reduces running of paints. Its extending properties are similar to those of ground quartz.

GYPSUM

Description

Gypsum theoretically contains 32.5 percent CaO, 46.6 percent SO_3, and 20.9 percent water. The crystalline form of gypsum, known as selenite, may approach the theoretical composition, but the massive and earthy forms, from which most of the commercial output is obtained, contain impurities of clay, silica, iron oxides, and calcium and magnesium carbonates. The gypsum used in paint is generally compact, fine-grained, and contains less than 1 percent impurities. Finely ground gypsum of this quality has special applications in calcined plasters and is also used to a small extent in the paint industry under the name of terra alba.

Gypsum is soft (hardness 2) and fairly lightweight (sp. gr., 2.3). The index of refraction is near 1.52, and the oil absorption is 20 to 25 percent.

Preparation

To produce terra alba, lumps of high-grade gypsum are scrubbed and rinsed with water, dried, ground in an emery or other fine-grinding mill, and bolted through silk or a 200-mesh screen.

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Use in Paint

Terra alba in oil is virtually transparent and is not used in oil paints except in primers and undercoatings. It finds its main outlet in whitewashes and calcimines, paritcularly for exterior concrete work, and in the manufacture of cheap lake pigments. One of the main requirements of a concrete paint is alkali resistance. Satisfactory alkali resistance may be obtained with a typical oil or varnish vehicle, when 15 to 20 percent of the pigment is plaster of Paris or terra alba, in combination with other suitable pigments.17/ Calcined gypsum also is used in calcimine; coloring matter and glue or casein generally are added, and a water suspension of the mixture may be applied satisfactorily to plaster, wood, burlap, and other materials. Occasionally some calcined gypsum (plaster of Paris) is used as a paint extender.

WHITING

Description

Finely ground, pulverized, powdered, or chemically precipitated calcium carbonate of good white color is known as whiting, and the various whitings are generally named according to the raw materials used in their preparation, as chalk whiting, limestone whiting, marble whiting, dolomite whiting, and precipitated whiting. The natural whiting formerly most used in paint was obtained from chalk, which consists mainly of the shells of minute marine organisms. Such whiting is sometimes called Paris white or Spanish white. A typical chemical analysis of chalk may show 94.7 percent calcium carbonate, 3.0 percent silica, 2.1 percent moisture, and 0.2 percent other organic matter. Pure limestone and marble whitings may approximate 99.5 percent or more calcium carbonate, and during recent years the finest of such whitings have been used to a considerable extent in paint.

English and French chalk generally contains from 85 to over 98 percent by volume of coccolithophores or their fragments, the remainder being foraminifera. Coccclithophores (commonly known as coccoliths) are tiny ball-like marine plants whose shells are composed of calcium carbonate.

Preparation

Chalk.- Several domestic companies, most of which are situated on the eastern seaboard, import crude chalk from Europe and prepare it as

17/ Fuller, W. R., Inert Materials for Admixture with Paint Pigments. A.S.T.M. bull. 105, August 1940, p. 37.

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chalk whiting. In the older types of mills, crude imported chalk is ground wet with edge runners. Material is brought to grinders in wheelbarrows or tram cars rather than by mechanical means, because by the former methods flint balls associated with the chalk may be picked out by hand. The milklike suspension of ground chalk is conveyed to a series of settling tanks. Sand settles first and is discarded as waste. A crude "commercial whiting" is obtained from the first tank. The overflow, which requires a longer period for settlement, supplies the "gilders" or "extra gilders" whiting deposited in the intermediate tanks. From these the overflow passes to final tanks, where a minus 40-microns product, Paris white, is deposited. The overflow from the last tank is returned to the grinding mills. When the pits are full, the sludge is allowed to settle completely, and the supernatant water is drawn off, leaving a mass of the consistency of cream. This is ladled out and carted to the drying sheds, where it is evaporated to partial dryness. The final drying, which may take several weeks, is accomplished in heated chambers. The dried product is disintegrated, passed through a bolting machine or air-separated, and packed in burlap bags of 50- or 100-pound capacity.

More modern methods of preparation make use of bowl classifiers, hydroseparators, and thickeners, and yield a very uniform product.

Limestone and marble whitings. - Limestone and marble are pulverized and graded by two processes - the wet and dry methods. For the manufacture of paint, water-ground whiting is said to be preferable. In the wet method, chips are ground in a pebble mill, the mill discharge being pumped to two settling cones. The settled product is returned to the mill, and the overflow is conveyed to settling tanks. The sediment from the tanks, containing about 50 percent moisture, is splashed on a steel drum internally heated with steam. A series of scrapers transfer the dried material to a screw conveyor. Lumps are broken by an impact pulverizer. In dry grinding, the stone may be coarse-ground in impact mills, fine-ground in ball mills, and classified in air separators.

More complete descriptions of whiting preparation appear in other reports.[18/]

Use in Paint

Whiting, like fibrous talc, is regarded as a standard extender for flat wall paints, and many formulas combine the two. A good grade of whiting has no marked disadvantages for wall paints; on the contrary, it promotes

18/ Bowles, O., Chalk and Whiting: Bureau of Mines Inf. Circ. 7197, 1942, 21 pp.; Wilson, H., and Skinner, K. G., Occurence, Properties, and Preparation of Limestone and Chalk for Whiting: Bureau of Mines Bull. 395, 1937, 160 pp.; and Heaton, work cited, pp. 106-7.

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good color, good flow, and a smooth film. Whiting has good pigment-suspending properties. It is rather low in flatting power, and its sanding properties are rather poor, as it has a tendency to clog the sandpaper.

It has been said that whiting probably should not be used in large quantities in outside paints, as it reacts on contact with moisture and carbon dioxide to form soluble calcium bicarbonate, but this point is in dispute. Small amounts, however, are said to be benificial, neutralizing free fatty acids in the vehicle that would otherwise catalyze decomposition of the paint film.19/

In inexpensive house paints, whiting has replaced hiding pigments to some extent without radically affecting the product. Whiting is used extensively in distempers and calcimines.

In some fields natural whiting has been replaced by precipitated and surface-treated whiting. In normal times whiting is relatively inexpensive.

MISCELLANEOUS EXTENDERS

Siliceous dolomite

A rock composed of calcium-magnesium carbonate (80.2 percent) and calcium-magnesium silicate (19.8 percent) has been quarried in Wisconsin for several years for use as a paint extender under the name of "metronite." Considerable quantities are used in house and flat paints and in enamel undercoats.

Slate flour

Slate production involves large quantities of waste, some of which is ground, air-classified, and sold as an inexpensive wood filler and paint extender. Slate consists essentially of fine-grained mica, chlorite, and quartz, together with smaller quantities of iron oxide, clay, organic matter, and other impurities.

Celestite

Celestite (strontium sulfate) is not used as an extender in the United States, as it cannot compete with barite in cost. However, in Great Britain, the world's largest source in normal times, it is available at so low a cost that it may be so used. As it is softer than barite, it is more easily ground, and the particles are smaller and more uniform. Iron impurities, not easily removed, generally prevent its competition with the highest grades of barite, even in England.

19/ Joachim, B., work cited, p. 64.

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Magnesite

Unburned magnesite, natural magnesium carbonate, gives a good dull or matt effect but settles out of the vehicle too easily. The settling can be inhibited by mixing with aluminum stearate, which acts as a suspension as well as a flatting agent. Very little magnesite is used in the paint industry.

Asbestos

Asbestos fiber cannot be used in paints that must present a thin, smooth film. Large quantities are used in roof coatings for fibrous reinforcement of the paint and to assist in sealing small holes in the roof surface; smaller quantities are consumed in texture paints to increase the durability of the finish. Asbestos is also used in fire-resistant paints.

PHYSICAL PROPERTIES OF SOME EXTENDERS

Product	Oil absorption, percent	Hardness	Pounds per solid gallon (approximate)	Particle size, microns 1/
Talc	15 - 40	1	24	5 - 10 (av.)
Mica	20 - 50	2.5 - 3	37	5 - 100 (range)
Clay	25 - 50	2	21	2 - 10 (av.)
Barite	6 - 9	2.5 - 3.5	37	5 - 100 (range)
Ground quartz	20 - 30	7	22	2 - 5 (av.)
Diatomite	35 - 300	5.5 - 6.5	16	1 - 40 (range)
Tripoli	35 - 50	5.5 - 6.5	20	5 - 8 (av.)
Gypsum	20 - 25	1.5 - 2.5	20	2 - 6 (av.)
Chalk whiting	10 - 20	3	23	0.1 - 10 (range)
Limestone whiting	10 - 20	3	22	5 - 10 (av.)
Siliceous dolomite	13	No data	22	2 - 5 (av.)
Celestite	No data	3 - 3.5	33	No data.
Magnesite	No data	3.5 - 4.5	24	No data.

1/ For the purpose of this table, "range" means the size limits within which virtually all of the particles fall, whereas "average" size means a narrower limitation intended to include the particle sizes present in the greatest quantities.

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AVERAGE PRICE QUOTATIONS OF NATURAL PREPARED MINERAL PAINT EXTENDERS, 1943

Product	Price per short ton at works, bulk
Talc	$13 - 43
Mica (wet-ground)	95
Sericite	30
Clay	7 - 105
Barite	25 - 36
Ground quartz	13 - 19
Diatomite	55 - 100
Tripoli	17 - 30
Gypsum	12
Chalk whiting (Paris white)	24 - 29
Limestone whiting	12 - 16

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